CERTIFICATE OF TRANSLATION

I, the undersigned, hereby certify

that I am well acquainted with the English and Japanese languages,

that I prepared the attached document, and

that, to the best of my knowledge and belief, the attached document is an accurate translation of the Japanese patent application JP 2004-028618 filed on February 4, 2004.

I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true.

Y. Naka

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October 6, 2009

Date

[Name of the Document] Claims

[Claim 1] A biosensor for measuring a test substance included in a sample, comprising:

a substrate;

a reaction section provided on said substrate and including a reagent section containing an enzyme reacting with the test substance as a substrate, said sample being supplied to said reaction section; and

a quality deciding section including a moisture absorbing material that is changed in color through absorption of moisture.

[Claim 2] The biosensor of Claim 1, wherein said enzyme is an oxidoreductase.

[Claim 3] The biosensor of Claim 2, wherein said reagent section further contains an electron mediator.

[Claim 4] The biosensor of Claim 3, further comprising:

a pair of terminals provided on said substrate; and

a pair of electrodes provided in said reaction section to be spaced from each other and respectively connected to said pair of terminals.

[Claim 5] The biosensor of Claim 1,

wherein said quality deciding section is in the shape of a sheet.

[Claim 6] The biosensor of Claim 1, further comprising a covering member made of a light blocking material and formed over said substrate for covering said reaction section.

[Claim 7] A method for fabricating a biosensor for measuring a test substance included in a sample, comprising the steps of:

(a) preparing a substrate including a through hole;

(b) providing, on said substrate, a reaction section including a reagent section containing an enzyme reacting with the test substance as a substrate, said sample being supplied to said reaction section;

(c) attaching a sheet including a moisture absorbing material, to a face of said substrate opposite to a face thereof on which said reaction section is provided; and

(d) attaching a sealing member for sealing said sheet.

[Claim 8] A biosensor measuring apparatus for measuring a test substance included in a sample by using a biosensor including a substrate; a reaction section provided on said substrate and including a reagent section containing an enzyme reacting with the test substance as a substrate, said sample being supplied to said reaction section; a quality deciding section including a moisture absorbing material that is changed in color through absorption of moisture, said biosensor measuring apparatus comprising:

a detecting section including a light source for irradiating said quality deciding section with light and a photo detecting device for receiving incident light emitted from said light source through said quality deciding section; and

a measuring section connected to said detecting section for measuring an optical characteristic of said incident light and for determining quality of said reagent section of said biosensor on the basis of said optical characteristic of said incident light.

[Name of the Document] Specification

[Title of the Invention] BIOSENSOR, METHOD FOR FABRICATING THE SAME, AND BIOSENSOR MEASURING APPARATUS

[Field of the Invention]

The present invention relates to a biosensor for more accurately measuring a test substance included in a sample.

[Prior Art]

Recently, various types of biosensors using a specific catalysis function of an enzyme have been developed as a quantitative analysis method for a saccharide such as sucrose or glucose.

Now, a quantitative analysis method for glucose will be described as an example of the quantitative analysis method for a saccharide included in a sample. As an electrochemical quantitative analysis method for glucose, a method using an enzyme of glucose oxidase (EC1.1.3.4; hereinafter abbreviated as GOD) and an oxygen electrode or a hydrogen peroxide electrode is generally known.

GOD selectively oxidizes a substrate of β-D-glucose into D-glucono-δ-lactone by using oxygen as an electron mediator. In the oxidation reaction caused by GOD in the presence of oxygen, oxygen is reduced to hydrogen peroxide. The amount of thus reduced oxygen is measured with the oxygen electrode or the amount of thus increased hydrogen peroxide is measured with the hydrogen peroxide electrode. The amount of reduced oxygen or the amount of increased hydrogen peroxide is proportional to the content of glucose in a sample, and therefore, the glucose is measured on the basis of the amount of reduced oxygen or the amount of increased hydrogen peroxide.

In the aforementioned method, the glucose included in the sample can be accurately measured by utilizing the specificity of the enzyme reaction. However, as is presumed from

the reaction process, this method has a disadvantage that it is largely affected by the concentration of oxygen included in the sample, and when the sample includes no oxygen, the measurement cannot be performed.

Therefore, a glucose measuring biosensor using, as an electron mediator, not oxygen but an organic compound or a metal complex such as potassium ferricyanide, a ferrocene derivative or a xenon derivative has been developed. In this glucose measuring biosensor, a reductant of the electron mediator resulting from an enzyme reaction is oxidized on a working electrode, thereby obtaining the concentration of glucose included in a sample on the basis of an oxidation current flowing in the oxidation. At this point, a reaction in which an oxidant of the electron mediator is reduced so as to generate the reductant of the electron mediator is proceeded on a counter electrode. When an organic compound or a metal complex is thus used as an electron mediator instead of oxygen, a reagent section can be formed by stably and accurately holding a known amount of GOD and the electron mediator on the electrode, and therefore, glucose can be accurately measured without being affected by the concentration of oxygen included in the sample. Also, since the reagent section including the enzyme and the electron mediator can be integrated with an electrode system in an almost dry state in this case, a disposable glucose measuring biosensor based on this technique is recently regarded remarkable. A typical example of such a biosensor is a biosensor described in Patent Document 1. In using a disposable glucose measuring biosensor, the concentration of glucose can be easily measured with a measuring apparatus by simply introducing a sample into the sensor removably connected to the measuring apparatus.

Exemplified measuring procedures for a blood glucose level (that is, a glucose concentration in blood) using the aforementioned disposable glucose measuring biosensor will be described.

First, a measurer takes a glucose measuring biosensor out of a package containing a

desiccant and fits it on a measuring apparatus. Thereafter, blood obtained by, for example, tapping a finger tip or the like with a needle is applied on the glucose measuring biosensor, and after a given period of time, the blood glucose level of the measurer is displayed on a displaying section of the measuring apparatus.

[Patent Document 1] Japanese Laid-Open Patent Publication No. 3-202764

[Disclosure of the Invention]

[Problems that the Invention is to solve]

For example, in the aforementioned glucose measuring biosensor, a reagent including an enzyme and an electron mediator is held in the reagent section in a dry state. When the reagent section absorbs the moisture of the air, however, it is apprehended that a part of the enzyme included in the reagent section is inactivated or that an organic compound or a metal complex used as the electron mediator is reformed. Also, the moisture of the air may not only inactivate the enzyme or reform the electron mediator but also affect the reaction of the enzyme or the electron mediator. Therefore, in using the aforementioned glucose measuring biosensor, it is strongly recommended for accurate measurement that the biosensor is taken out of the package immediately before the measurement, but it is given into the hands of a measurer to determine when the biosensor is to be taken out.

In using conventional biosensors including the aforementioned glucose measuring biosensor, however, it is difficult for an ordinary user to determine the performance of a biosensor taken out of its package or the like.

The present invention was devised in consideration of these circumstances, and an object is providing a biosensor and a biosensor measuring apparatus whose performance can be easily determined by an ordinary user.

[Means for Solving the Problems]

The biosensor of this invention for measuring a test substance included in a sample

includes a substrate; a reaction section provided on said substrate and including a reagent section containing an enzyme reacting with the test substance as a substrate, said sample being supplied to said reaction section; and a quality deciding section including a moisture absorbing material that is changed in color through absorption of moisture.

In the case where the biosensor of this invention is packed in, for example, an arbitrary package in the form of distribution, after it is taken out of the package, as it is exposed to the air for a longer time, the moisture absorbing material absorbs moisture of the air, and hence, the quality deciding section is changed in color from its portion exposed to the air through a reaction with the absorbed moisture. Accordingly, a user can make the following decision: The measurement is performed before the quality deciding section of the biosensor is changed in color, and if the color-changed biosensor is not used and is replaced with a new biosensor based on the determination that the reagent section has been degraded. Accordingly, an ordinary user can always easily use a biosensor with performance suitable for use without necessity of special knowledge and technique, and hence, accurate measurement can be always performed.

The enzyme may be an oxidoreductase.

The reagent section may further contain an electron mediator.

The biosensor may further include: a pair of terminals provided on said substrate; and a pair of electrodes provided in said reaction section to be spaced from each other and respectively connected to said pair of terminals.

The quality deciding section may be in the shape of a sheet.

The biosensor may further include a covering member made of a light blocking material and formed over said substrate for covering said reaction section.

A method for fabricating a biosensor according to the present invention is a method for fabricating a biosensor for measuring a test substance included in a sample. The method

includes the steps of: (a) preparing a substrate including a through hole; (b) providing, on said substrate, a reaction section including a reagent section containing an enzyme reacting with the test substance as a substrate, said sample being supplied to said reaction section; (c) attaching a sheet including a moisture absorbing material, to a face of said substrate opposite to a face thereof on which said reaction section is provided; and (d) attaching a sealing member for sealing said sheet.

With the inventive method for fabricating a biosensor, the process for forming the quality deciding section can be extremely simplified. Accordingly, time when the sheet is exposed to the air can be largely reduced, and hence, degradation of the quality deciding section during the fabrication can be extremely suppressed. Therefore, it can be more accurately decided whether or not the reagent section of the biosensor has performance suitable for use.

A biosensor measuring apparatus according to the present invention is a biosensor measuring apparatus for measuring a test substance included in a sample by using a biosensor including a substrate; a reaction section provided on said substrate and including a reagent section containing an enzyme reacting with the test substance as a substrate, said sample being supplied to said reaction section; a quality deciding section including a moisture absorbing material that is changed in color through absorption of moisture, said biosensor measuring apparatus including: a detecting section including a light source for irradiating said quality deciding section with light and a photo detecting device for receiving incident light emitted from said light source through said quality deciding section; and a measuring section connected to said detecting section for measuring an optical characteristic of said incident light and for determining quality of said reagent section of said biosensor on the basis of said optical characteristic of said incident light.

In using the biosensor measuring apparatus of this invention, the color change of the

quality deciding section of the biosensor is detected, and therefore, it can be determined whether or not the biosensor is suitable for use. Accordingly, when the biosensor and the biosensor measuring apparatus are used, a measurer can automatically perform accurate measurement without necessity of special knowledge.

[Advantages of the Invention]

The present invention provides a biosensor in which a user can easily determine whether or not its performance is suitable for use, and a biosensor measuring apparatus.

[Embodiments of the Invention]

Preferred embodiments of the invention will now be described in detail on the basis of the accompanying drawings. It is noted that a word "connection" herein means "electrical connection" unless otherwise mentioned. Also, elements commonly used in the respective embodiments are referred to by using common reference numerals for simplification.

(EMBODIMENT 1)

In this embodiment, a biosensor to be used for measuring glucose will be described as an example. As also described later, the present embodiment is not intended to limit the invention to a biosensor for measuring glucose as a test substance.

The biosensor according to this embodiment will be described with reference to FIGS. 1A and 1B. FIG. 1A is an exploded perspective view of the biosensor of this embodiment and FIG. 1B is a cross-sectional view thereof taken on line X-X of FIG. 1A.

As shown in FIG. 1A and 1B, the biosensor 100 of this embodiment includes a substrate 1 having a quality deciding section 13 and a reaction section 15 provided on the substrate 1 to which a sample is supplied. The quality deciding section 13 includes a moisture absorbing material that is changed in color through absorption of moisture. The reaction section 15 has a reagent section 7 including an enzyme reacting with a test substance as a substrate.

In this embodiment, the quality deciding section 13 includes a recess 17 formed in the substrate 1, the moisture absorbing material 16 provided in the recess 17 and a film with air permeability (which is an air-permeable film in this embodiment) provided to cover the opening of the recess 17. In this embodiment, cobalt salt is used as the moisture absorbing material 16.

In the biosensor 100 of this embodiment, the substrate 1 is made of an electrically insulating material, and the biosensor 100 has terminals 2 and 3 formed on the substrate 1 and terminals 4 and 5 provided in the reaction section 15 to be spaced from each other and respectively connected to the terminals 2 and 3. Specifically, the electrode 4 is patterned in a rectangular shape, and the electrode 5 is patterned to be spaced from and to surround the electrode 4. In this embodiment, the electrode 4 and the electrode 5 are respectively covered with conductive carbon pastes 4a and 5a including a resin binder. Furthermore, an insulating film 6 is formed so as to cover a region where a spacer member 8 described below is provided on the substrate 1 and the peripheral portion of the electrode 4, and a portion of the insulating film 6 covering the peripheral portion of the electrode 4 defines the area of an exposed portion of the electrode 4.

The reagent section 7 is provided so as to cover the electrodes 4 and 5 and includes, as a reagent, GOD, that is, an oxidoreductase, and potassium ferricyanide, that is, an electron mediator. In this embodiment, specifically, the reagent section 7 is formed by dropping an aqueous solution of an oxidoreductase of GOD and an electron mediator of potassium ferricyanide onto the electrodes 4 and 5 and drying the aqueous solution. Furthermore, a surfactant layer 12 is formed so as to cover the reagent section 7.

The biosensor of this embodiment further includes the spacer member 8 provided on the substrate 1 and having a slit 10 and a cover 9 provided so as to sandwich the spacer member 8 together with the substrate 1 and having an air hole 11. The slit 10 forms the

reaction section 15 between the substrate 1 and the cover 9. The air hole 11 of the cover 9 is communicated with the reaction section 15, so that a sample can easily reach the reagent section 7 disposed within the reaction section 15 through the capillarity by merely bringing the sample into contact with a sample supply port 10a formed on the open end of the slit 10.

In the biosensor 100 of this embodiment, when a sample is allowed to come in contact with the sample supply port 10a, the sample reaches the reagent section 7 provided within the reaction section 15 and the surfactant layer 12 is dissolved in the sample in the reagent section 7, so as to cause an enzyme reaction. After a predetermined period of time, when a given potential difference is applied between the terminals 2 and 3 so that the electrode 4 and the electrode 5 can respectively work as a working electrode and a counter electrode, a reductant of the electron mediator resulting from the enzyme reaction is oxidized on the electrode 4. The concentration of glucose contained in the sample can be obtained on the basis of the oxidation current thus caused. At this point, a reaction for reducing an oxidant of the electron mediator to generate the reductant of the electron mediator is proceeded on the electrode 5.

The biosensor 100 of this embodiment was actually used for measuring a glucose concentration by using a solution including a given amount of glucose as a sample. Specifically, when a given period of time elapsed after supplying the sample through the sample supply port 10a to the reaction section 15, a voltage of 500 mV on the basis of a voltage on the electrode 5 was applied to the electrode 4. After this voltage application, a value of a current flowing between the electrode 4 and the electrode 5 was measured. Thus, a current response in proportion to the glucose concentration in the sample was observed.

The biosensor 100 of this embodiment is packed in, for example, an arbitrary package in the form of distribution, and immediately after taking it out of the package, the quality deciding section 13 assumes a blue color owing to the moisture absorbing material 16.

However, as it is exposed to the air for a longer time, the moisture absorbing material 16 absorbs moisture of the air, and through a reaction with the absorbed moisture, the color of the quality deciding section 13 is gradually changed to a pink color. Accordingly, a user can decide to perform measurement when the quality deciding section 13 of the biosensor 100 is blue, or decide that the biosensor which is changed to pink is deemed to show degradation of the reagent section 7, is not used, and is replaced with a new biosensor. Therefore, an ordinary user can always easily use a biosensor having suitable performance without necessity of special knowledge and technique, and accurate measurement can be always performed. The color change of the quality deciding section 13 derives from the property of the cobalt salt used as the moisture absorbing material 16 that it assumes a blue color when dried and assumes a pink color when absorbing moisture. Accordingly, when another material is used as the moisture absorbing material 16, the quality of the biosensor can be decided in accordance with the property in color change of the material between a dry state and a moisture absorbing state.

The color change of the quality deciding section 13 may be visually checked by a measurer, which does not limit the invention. For example, a device for detecting the color change of the quality deciding section 13 may be used. An example of such a device will be described in detail in Embodiment 2 below. The position of the quality deciding section 13 is not limited to that described in this embodiment.

Also, the moisture absorbing material 16 of this embodiment may be any substance that is changed in color through absorption of moisture. For example, cobalt salt such as cobalt chloride or cobalt bromide may be used.

Also, the voltage applied to the electrode 4 is 500 mV on the basis of the voltage of the electrode 5 in this embodiment, which does not limit the invention, but the voltage may be any voltage at which the electron mediator can react on the electrode 4.

As described above, the biosensor for measuring glucose by using a β-D-glucose aqueous solution as a sample is described as an example in this embodiment, which does not limit the invention. For example, a biological sample such as whole blood, blood plasma, blood serum, interstitial fluid, saliva or urine may be used.

Furthermore, the test substance of the biosensor 100 of this embodiment is not limited to glucose. For example, the test substance of the biosensor may be a substance included in a biological sample such as whole blood, blood plasma, blood serum, interstitial fluid, saliva or urine. It is noted that whole blood herein means blood that has not been subjected to special processing, such as capillary blood, venous blood or arterial blood obtained by tapping, for example, a finger tip or a skin of an arm.

In the case where the test substance is a substance other than glucose, it is necessary to select an enzyme reacting with the test substance as a substrate. Although GOD, that is, an oxidoreductase, is used as the enzyme included in the reagent section 7 in this embodiment, an oxidoreductase other than GOD (such as fructose dehydrogenase, glucose dehydrogenase, alcohol oxidase, lactate oxidase, cholesterol oxidase, xanthine oxidase or amino acid oxidase) may be used.

Examples of the electron mediator are potassium ferricyanide, p-benzoquinone, phenazine methosulfate, methylene blue, a ferrocene derivative and the like. Also in the case where oxygen is used as the electron mediator, a current response can be obtained. Instead of using one of these substances as the electron mediator, a combination of two or more of them may be used.

Next, a method for fabricating the biosensor 100 of this embodiment will be simply described.

First, a silver paste or the like is printed by screen printing on an electrically insulating substrate 1 of poly(ethylene terephthalate) or the like in which a recess 16 is

previously formed, thereby forming a terminal 2 and a terminal 3. Subsequently, a conductive carbon paste including a resin binder is printed on the substrate 1, thereby forming an electrode 4 connected to the terminal 2. Thereafter, an insulating paste is printed on the substrate 1, thereby forming an insulating film 6 that covers the peripheral portion of the electrode 4 so as to define the area of an exposed portion of the electrode 4.

Next, a conductive carbon paste including a resin binder is printed on the substrate 1, thereby forming an electrode 5 connected to the terminal 3.

Then, an aqueous solution including an oxidoreductase of GOD and an electron mediator of potassium ferricyanide is dropped on the electrode 4 and the electrode 5, and the solution is dried so as to form a reagent section 7. Thereafter, a surfactant layer 12 including lecithin, that is, a surfactant, is formed on the reagent section 7.

Next, a spacer member 8 is adhered on the insulating film 6, and a cover 9 having an air hole 11 is adhered on the spacer member 8.

Ultimately, a moisture absorbing material 16 of cobalt salt is put in the recess 17 of the substrate 1 and a film 18 is adhered onto the substrate 1, thereby forming a quality deciding section 13. Thereafter, the resultant biosensor 100 is immediately packed in a package containing a desiccant for storage.

The GOD is used as the enzyme and the potassium ferricyanide is used as the electron mediator in the reagent section 7 of this embodiment, which does not limit the invention. Other specific examples of the enzyme and the electron mediator are described above.

Furthermore, the reagent section is formed by applying and drying the solution including the oxidoreductase in this embodiment, which does not limit the invention. For example, a solution including an oxidoreductase may be applied by an ink jet method. In this case, even when a small amount of solution is applied, the position for forming the

reagent section 7 can be accurately controlled. Alternatively, with a solution including an oxidoreductase held on glass filter paper, the glass filter paper may be dried and provided in the reaction section 15, or an oxidoreductase may be held in the reaction section 15 by a freeze-dry method. Further alternatively, the electrode may be formed by mixing a conductive material and a reagent.

The reagent section 7 is preferably positioned on the electrode 4 or the electrode 5, which does not limit the invention, but it may be positioned in any place in the sample supplying section 15 other than on the electrode 4 or the electrode 5 as far as it can come into contact with a sample.

In this embodiment, the substrate 1 and the spacer member 8 may be made of any material that has an electric insulating property and has sufficient rigidity for storage of the biosensor 100 and measurement with the biosensor. Examples of the material for the substrate 1 are a thermoplastic resin such as poly(ethylene terephthalate), polyethylene, polystyrene, poly(vinyl chloride), polyamide or a saturated polyester resin, and a thermosetting resin such as a urea resin, a melamine resin, a phenol resin, an epoxy resin or an unsaturated polyester resin. In particular, poly(ethylene terephthalate) is preferably used for the substrate 1 from the viewpoint of adhesion to the electrode.

Also, the spacer member 8 and the cover 9 are preferably made of a light blocking material. Thus, the enzyme and the electron mediator included in the reagent section 7 can be protected from light such as UV that may harmfully affect them.

The terminals 2 and 3 and the electrodes 4 and 5 are formed by the screen printing in this embodiment, which does not limit the invention. For example, a method in which a noble metal such as palladium is sputtered onto the substrate and an electrode pattern is formed by laser trimming or a method in which an electrode pattern is formed by photolithography may be employed.

The electrodes 4 and 5 may be made of any conductive material that is not oxidized through oxidation of the electron mediator. Examples of the material are carbon, palladium, gold and platinum. Alternatively, the electrode may be formed by covering an electric insulating material with such a conductive material.

Furthermore, the position of the air hole 11 is not limited to that shown in the drawing, but the air hole 11 may be provided in any place that is communicated with the reaction section 15 and where the capillarity is caused for introducing a sample from the sample supply port 10a to the reaction section 15. Specifically, it is positioned on one end of the slit 10 opposite to the sample supply port 10a.

(EMBODIMENT 2)

A biosensor according to this embodiment will be described with reference to FIGS. 2A and 2B. FIG. 2A is an exploded perspective view of the biosensor 100a of this embodiment and FIG. 2B is a cross-sectional view thereof taken on line Y-Y of FIG. 2A.

As shown in FIGS. 2A and 2B, the biosensor 100a of this embodiment has substantially the same structure as the biosensor 100 of Embodiment 1 described above and is different in a quality deciding section 13a alone from the biosensor 100.

The quality deciding section 13a is made of a sheet material including a moisture absorbing material 16a and is adhered onto a substrate 1. It is noted that cobalt salt is used as the moisture absorbing material. In the structure of this embodiment, since there is no need to form a recess or the like in the substrate 1, the fabrication of the biosensor is eased.

Needless to say, also when the biosensor 100a of this embodiment is used, an ordinary user can always easily use a biosensor having performance suitable for use without necessity of special knowledge and technique, and hence, accurate measurement can be always performed.

(EMBODIMENT 3)

A biosensor according to this embodiment will be described with reference to FIGS. 3A and 3B. FIG. 3A is an exploded perspective view of the biosensor 100b of this embodiment and FIG. 3B is a cross-sectional view thereof taken on line Z-Z of FIG. 3A.

As shown in FIGS. 3A and 3B, the biosensor 100b of this embodiment has substantially the same structure as the biosensor 100 of Embodiment 1. However, the biosensor 100b is different from the biosensor 100 in the following points: A substrate 1 has a through hole 17b, a moisture absorbing sheet 16b is adhered to a lower face of the substrate 1, a sealing member 19 (which is a sealing resin in this embodiment) is adhered to the lower face of the moisture absorbing sheet 16b, and a quality deciding section 13b is provided in the through hole 17b. It is noted that a sheet material including cobalt salt is used as the moisture absorbing sheet 16b.

Needless to say, also when the biosensor 100b of this embodiment is used, an ordinary user can always easily use a biosensor with performance suitable for use without necessity of special knowledge and technique, and accurate measurement can be always performed.

In particular, the biosensor 100b of this embodiment can be easily fabricated. This will be described with reference to FIGS. 4A and 4B. FIGS. 4A and 4B are cross-sectional views for showing procedures in a fabrication method for the biosensor 100b of this embodiment.

First, in the procedure shown in FIG. 4A, a silver paste or the like is printed on an electrically insulating substrate 1 of poly(ethylene terephthalate) or the like in which a through hole 17b is previously formed, thereby forming terminals 2 and 3. Subsequently, a conductive carbon paste including a resin binder is printed on the substrate 1, thereby forming an electrode 4 connected to the terminal 2. Thereafter, an insulating paste is printed on the substrate 1, thereby forming an insulating film 6 covering the peripheral portion of the

electrode 4 so as to define the area of an exposed portion of the electrode 4. Then, a conductive carbon paste including a resin binder is printed on the substrate 1, thereby forming an electrode 5 connected to the terminal 3.

Subsequently, an aqueous solution including GOD, that is, an oxidoreductase, and potassium ferricyanide, that is, an electron mediator, is dropped on the electrode 4 and the electrode 5, and the solution is dried so as to form a reagent section 7. Thereafter, a surfactant layer 12 including lecithin, that is, a surfactant, is formed on the reagent section 7. Then, a spacer member 8 is adhered onto the insulating film 6, and a cover 9 having an air hole 11 is adhered onto the spacer member 8.

Next, in the procedure shown in FIG. 4B, a moisture absorbing sheet 16b is adhered to the lower face of the substrate 1, and a sealing member 19 (which is a plastic sheet in this embodiment) is adhered to the lower face of the moisture absorbing sheet 16b. Thus, a quality deciding section 13b is formed.

In the case where a plurality of biosensors 100b are fabricated at one time on one substrate in each of the aforementioned procedures, the substrate is ultimately divided into the respective biosensors 100b.

Thereafter, each biosensor 100b is immediately packed in a package containing a desiccant for storage.

As described above, in the fabrication of the biosensor 100b of this embodiment, after forming a plurality of biosensors 100b at one time on one substrate, the substrate can be ultimately divided into the respective biosensors 100b. Therefore, a large number of biosensors can be easily fabricated.

Also, in the fabrication of the biosensor 100b of this embodiment, the process for forming the quality deciding section 13b can be extremely simplified (or substantially eliminated). Accordingly, time when the moisture absorbing sheet 16b is exposed to the air

can be largely reduced, and hence, degradation of the quality deciding section 13 during the fabrication can be extremely suppressed. Therefore, it can be more accurately decide whether or not the reagent section 7 of the biosensor has performance suitable for use.

(EMBODIMENT 4)

In this embodiment, a biosensor measuring apparatus to be connected to the biosensor 100 of Embodiment 1 for use will be described with reference to FIGS. 5 and 6. FIG. 5 is a schematic perspective view for showing the structure of the biosensor measuring apparatus of this embodiment and schematically shows a biosensor to be fitted thereon. FIGS. 6A and 6B are cross-sectional views for schematically showing the operation of the biosensor measuring apparatus of this embodiment performed in measurement with the biosensor.

As shown in FIG. 5, the biosensor measuring apparatus 200 of this embodiment includes a pair of connectors 21 and 22, a detecting section 23, a measuring section 24 connected to the pair of connectors 21 and 22 and the detecting section 23, a data processing section 25 connected to the measuring section 24, and a data displaying section 26 connected to the data processing section 25. In this embodiment, the pair of connectors 21 and 22, the detecting section 23, the measuring section 24, the data processing section 25 and the data displaying section 26 are housed in a housing 200a. The housing 200a has a slot (not shown) through which the biosensor 100 can be inserted.

The pair of connectors 21 and 22 are respectively connected to the terminal 2 and the terminal 3 of the biosensor 100 when the biosensor 100 is fitted on the biosensor measuring apparatus 200.

When the biosensor 100 is fitted through the slot of the biosensor measuring apparatus 200, the detecting section 23 detects the color change of the quality deciding section 13 and outputs the thus obtained optical characteristic to the measuring section 24.

The detecting section 23 of this embodiment has a light source and a photo detecting device, and is provided, as shown in FIG. 6A, so that the light source can emit light to the quality deciding section 13 of the biosensor 100 and that light reflected by the quality deciding section 13 can enter the photo detecting device. As the light source, a light emitting diode, a semiconductor laser or the like is used, and as the photo detecting device, a photo diode, a photo transistor or the like is used. The photo detecting device detects the incident light entering from the quality deciding section 13.

The measuring section 24 measures, on the basis of the output from the detecting section 23, optical characteristic data such as a wavelength spectral pattern of the incident light or the intensity of light of a specific wavelength and determines, on the basis of the obtained optical characteristic data, whether or not the degradation degree of the reagent section 7 of the biosensor 100 is suitable for measurement, and in the case where the performance of the reagent section 7 is suitable for the measurement, a value of a current flowing between the electrode 4 and the electrode 5 is measured through the pair of connectors 21 and 22. For example, in the case where the biosensor 100 of the embodiment is connected for use, when the detecting section 23 detects that the color of the quality deciding section 13 is blue, the measurement is performed after a measurement standby state, so as to output measured data to the data processing section 25. If the detecting section 23 detects that the color of the quality deciding section 13 is pink, data that the biosensor is unsuitable for the measurement is output to the data processing section 25.

When the measured data is input, the data processing section 25 digitizes the measured data and outputs the digitized data to the data displaying section 26. When the data that the biosensor is unsuitable for the measurement is input, the data processing section 25 outputs an instruction for making the data displaying section 26 display that the biosensor is unsuitable for the measurement.

The data displaying section 26 produces a display in accordance with the data or the instruction output from the data processing section 25.

In particular, in this embodiment, when the biosensor 100 is fitted in the slot of the biosensor measuring apparatus 200, the quality deciding section 13 of the biosensor 100 is disposed within the biosensor measuring apparatus 200. Therefore, the color change of the quality deciding section 13 can be detected in the detecting section 23 of the biosensor measuring apparatus 200, so as to determine whether or not the biosensor is suitable for use. When the biosensor 100 and the biosensor measuring apparatus 200 are thus used, a measurer can automatically perform accurate measurement without necessity of special knowledge.

At this point, examples of the positional relationship between the detecting section 23 provided in the biosensor measuring apparatus 200 and the biosensor 100 will be shown in FIGS. 6A and 6B.

As shown in FIG. 6A, in the detecting section 23 of the biosensor measuring apparatus 200 of this embodiment, the light source of the detecting section is disposed above the quality deciding section 13 of the biosensor 100, and the photo detecting device is disposed in a position for receiving light emitted from the light source and reflected at approximately 45 degrees. Thus, the color change of the quality deciding section 13 (namely, the moisture absorbing material 16) is detected on the basis of the reflected light.

Alternatively, as shown in FIG. 6B, the light source and the photo detecting device of the detecting section 23 may be disposed so as to sandwich a biosensor 100c for measuring light passing through a quality deciding section 13c. The biosensor 100c of FIG. 6B has substantially the same structure as the biosensor 100b of Embodiment 3 and is different from the biosensor 100b of Embodiment 3 in the quality deciding section 13c of the biosensor 100c has an opening in a region of the sealing member 19 facing the opening 17.

The quality deciding section 13 of the biosensor 100 is disposed between the

electrode 4 and the electrode 5 in this embodiment, which does not limit the invention. The quality deciding section 13 is not particularly specified as far as it is disposed within the biosensor measuring apparatus 200 when the biosensor 100 is fitted in the slot of the biosensor measuring apparatus 200 and the detecting section 23 can detect the color change of the quality deciding section 13 (i.e., the moisture absorbing material 16).

Also, although the biosensor 100 is fitted on the biosensor measuring apparatus 200 in this embodiment, it goes without saying that the biosensor 100a or 100b of Embodiment 2 or 3 may be fitted thereon for use.

(OTHER EMBODIMENTS)

Each of the biosensors 100, 100a, and 100b of Embodiments 1 through 3 has a structure in which a test substance is electrochemically detected (namely, the biosensors are electrochemical biosensors), which does not limit the invention. Now, an example of a biosensor having another structure will be described with reference to FIGS. 7A and 7B. FIG. 7A is a perspective view of a biosensor for optically detecting a test substance and FIG. 7B is a cross-sectional view thereof taken on line W-W of FIG. 7A.

As shown in FIGS. 7A and 7B, the biosensor 100' includes a substrate 1 having a quality deciding section 13 and a reaction section 15' provided on the substrate 1 to which a sample is supplied. The quality deciding section 13 includes a moisture absorbing material that is changed in color through absorption of moisture.

In the biosensor 100', the quality deciding section 13 includes a recess 17 formed in the substrate 1, the moisture absorbing material 16 provided in the recess 17 and a film with air permeability (which is an air-permeable film in this embodiment) provided to cover the opening of the recess 17. It is noted that cobalt salt is used as the moisture absorbing material 16.

The reaction section 15' includes a recess 25 formed in the substrate 1, a reagent

section 26 provided in the recess 25 and including an enzyme reacting with a test substance as a substrate and a permeable film 27 provided so as to cover the opening of the recess 25 and capable of permeating moisture. In particular, in the biosensor 100', the test substance is detected by measuring the color change of the reaction section 15'. The reagent section 26 employs, for example, a structure in which the included enzyme assumes a color or fluoresces through an enzyme reaction, a structure further including a pH indicator that assumes a color through change of pH caused by an enzyme reaction, a structure in which color change is caused by reduction of the substrate through an enzyme reaction or the like.

In this manner, even with the biosensor 100' optically detecting a test substance, the presence of the quality deciding section 13 allows a user to determine whether the reagent section 26 of the biosensor 100' is suitable for measurement or not, completely in the same manner as in the biosensors of Embodiments 1 to 3.

[Industrial Applicability]

As described so far, the biosensor and the biosensor measuring apparatus of this invention are useful for measurement or the like performed in a medical diagnosis in which it is necessary to more accurately measure a test substance included in a sample.

[Brief Description of the Drawing]

[Figure 1] FIG. 1A is an exploded perspective view of a biosensor according to Embodiment 1 and FIG. 1B is a cross-sectional view thereof taken on line X-X of FIG. 1A.

[Figure 2] FIG. 2A is an exploded perspective view of a biosensor according to Embodiment 2 and FIG. 2B is a cross-sectional view thereof taken on line Y-Y of FIG. 2A.

[Figure 3] FIG. 3A is an exploded perspective view of a biosensor according to Embodiment 3 and FIG. 3B is a cross-sectional view thereof taken on line Z-Z of FIG. 3A.

[Figure 4] FIGS. 4A and 4B are cross-sectional views for showing procedures in a method for fabricating the biosensor of Embodiment 3.

[Figure 5] FIG. 5 is a schematic perspective view for showing the structure of a biosensor measuring apparatus according to Embodiment 4 in which a biosensor to be fitted thereon is schematically shown.

[Figure 6] FIGS. 6A and 6B are schematic cross-sectional views for showing an operation of the biosensor measuring apparatus of Embodiment 4 for measurement with a biosensor.

[Figure 7] FIG. 7A is a perspective view of a biosensor for optically detecting a test substance and FIG. 7B is a cross-sectional view thereof taken on line W-W of FIG. 7A.

[Description of the Reference Numerals]

1: substrate

2, 3: terminals

4, 5: electrodes

4a, 5a: conductive carbon pastes

6: insulating film

7: reagent section

8: spacer member

9: cover

10: slit

10a: sample supply port

11: air hole

12: surfactant layer

13, 13a, 13b, 13c: quality deciding section

15, 15': reaction section

16, 16a: moisture absorbing material

16b, 16c: moisture absorbing sheet

17: recess

17b: through hole

18: film

19: impermeable cover sheet

20: quality deciding position

21, 22: connectors

23: detecting section

24: measuring section

25: data processing section

26: data displaying section

100, 100a, 100b, 100c: biosensor

200: measuring apparatus

200a: housing

[Name of the Document] Abstract

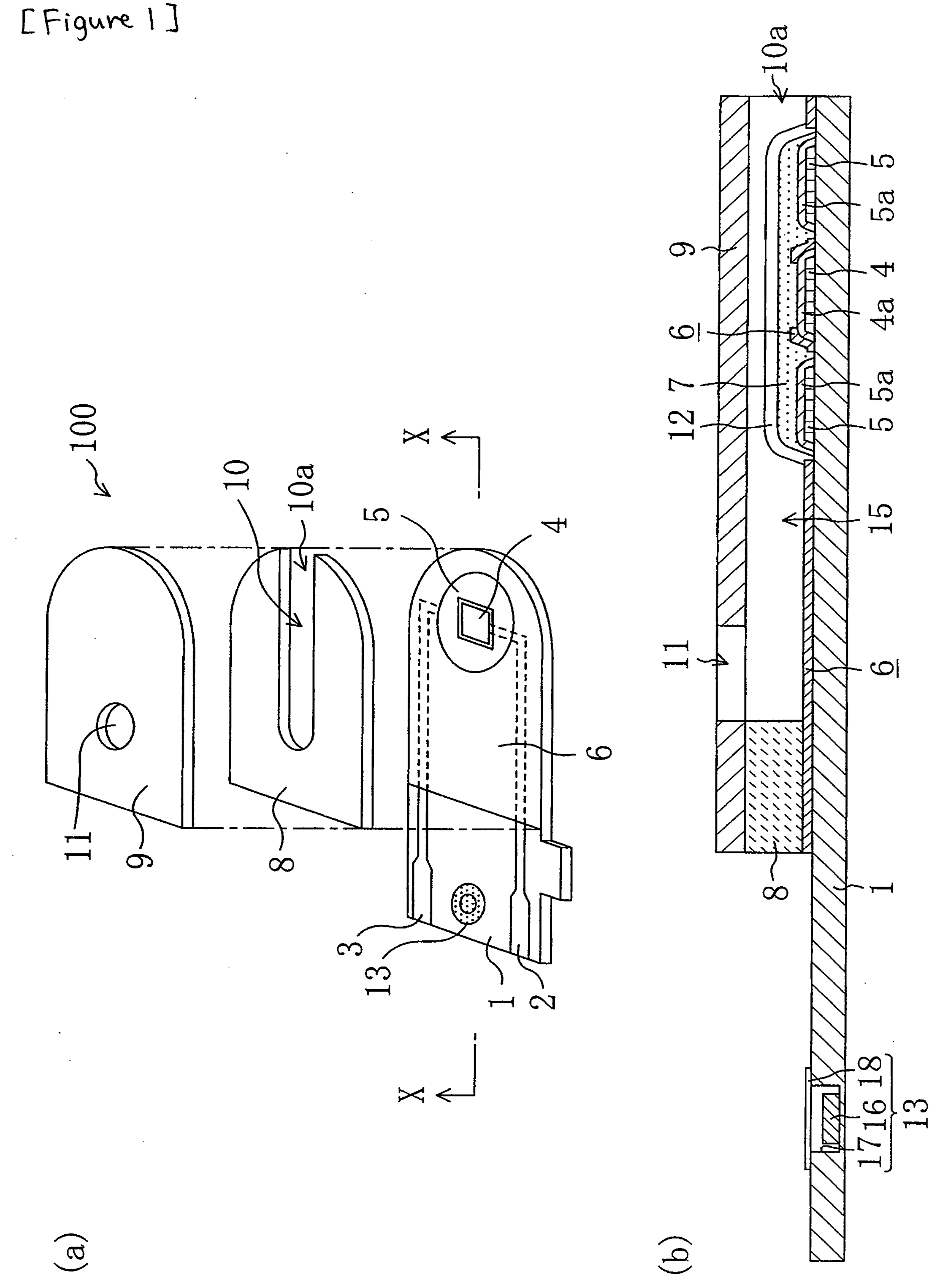
[Abstract]

[Problems] A biosensor and a biosensor measuring apparatus whose performance can be easily determined by an ordinary user are provided.

[Solution] A biosensor 100 includes a substrate 1 having a quality deciding section 13 and a reaction section 15 provided on the substrate 1 to which a sample is supplied. The quality deciding section 13 includes a moisture absorbing material changed in color through absorption of moisture. The reaction section 15 has a reagent section 7 including an enzyme reacting with a test substance as a substrate. The quality deciding section 13 includes a recess 17 formed in the substrate 1, the moisture absorbing material 16 disposed in the recess 17 and a film with air permeability (which is an air-permeable film) provided to cover the opening of the recess 17. Cobalt salt is used as the moisture absorbing material 16.

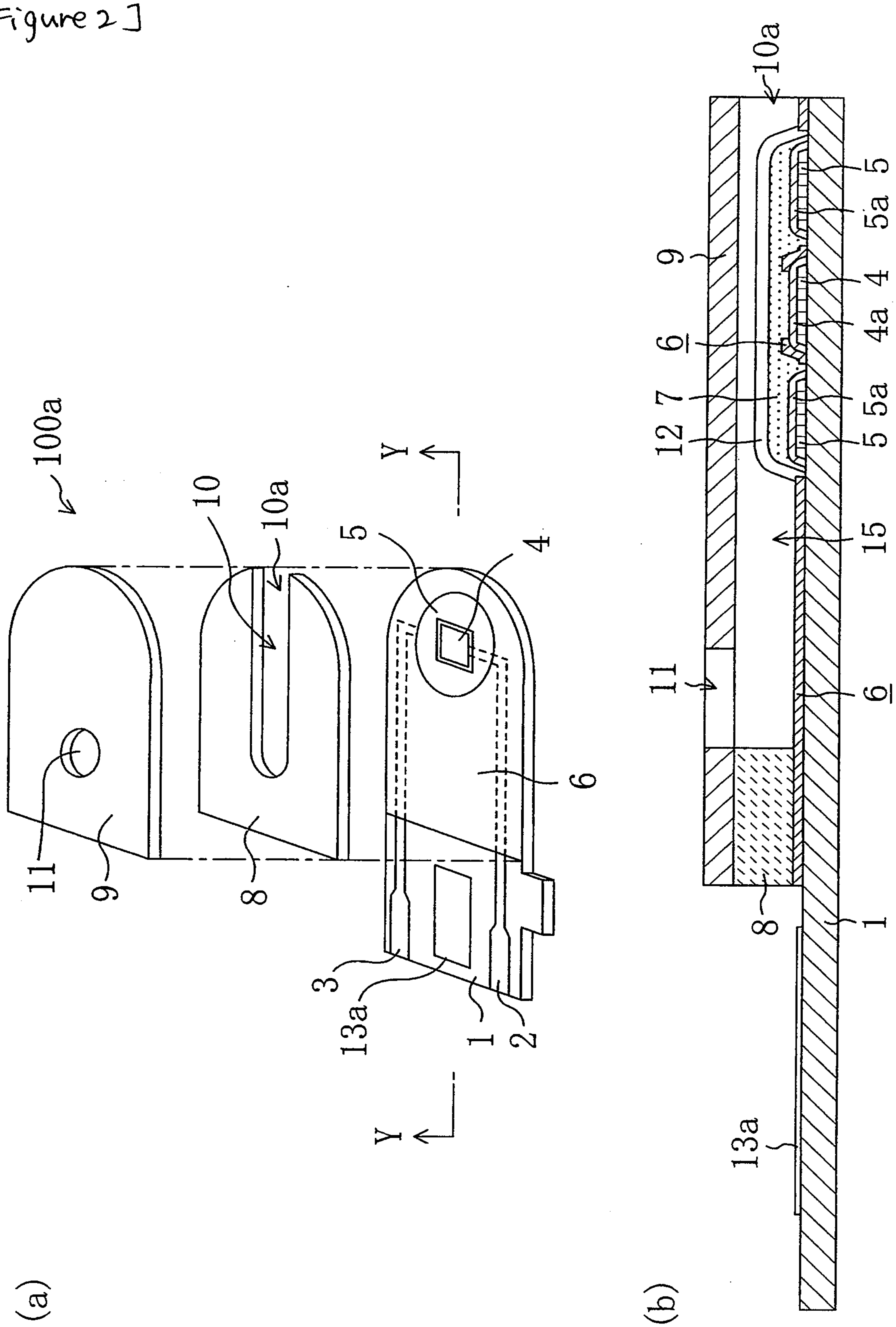
[Selected Figure] Figure 1

【書類名】図面 [Name of the Document]
【図１】
[Figure 1]



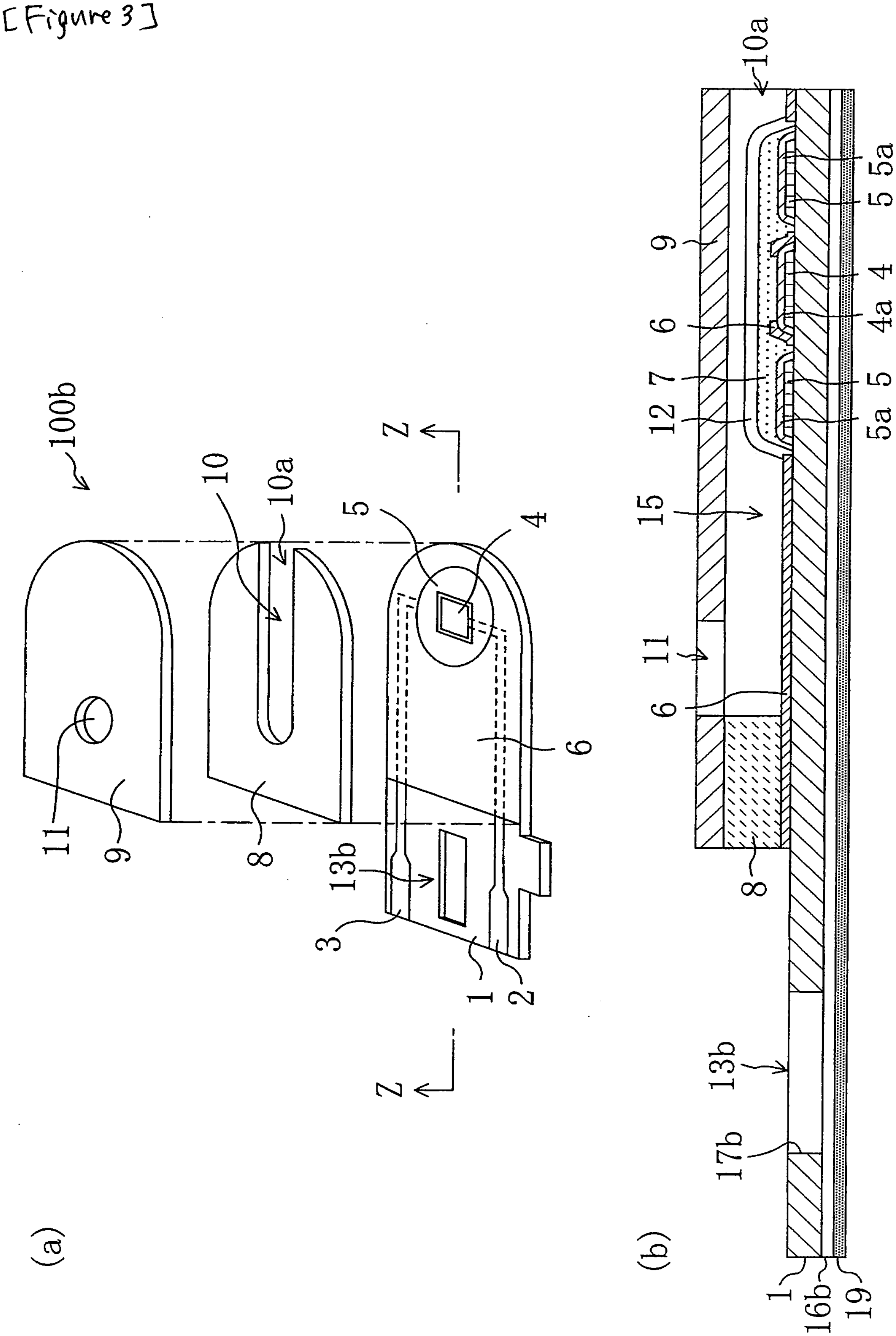
【図２】

[Figure 2]



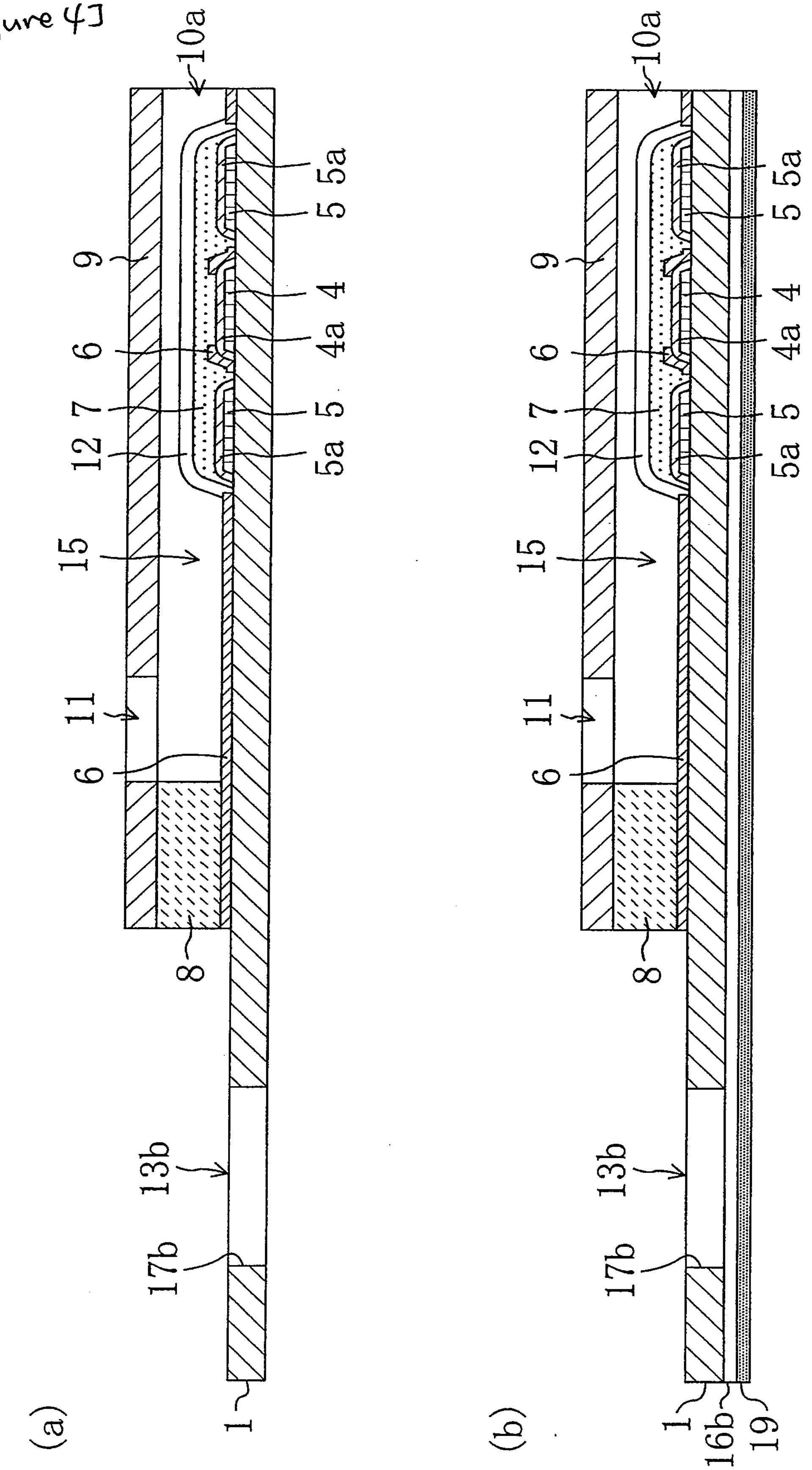
【図３】

[Figure 3]


(a)
100b
10
10a
5
4
Z
Z
11
9
8
13b
3
1
2
6
(b)
10a
9
5a
5
4
6
4a
7
5
12
5a
15
11
6
8
13b
17b
1
16b
19

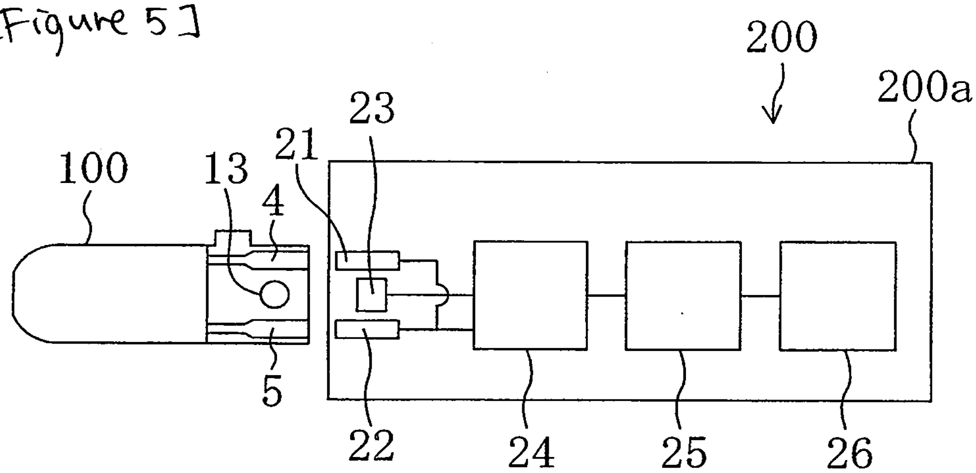
【図４】

[Figure 4]


10a
9
5 5a
5
4
6
4a
12 7
5
5a
15
11
6
8
13b
17b
1
(a)
10a
9
5 5a
5
4
6
4a
12 7
5
5a
15
11
6
8
13b
17b
1
16b
19
(b)

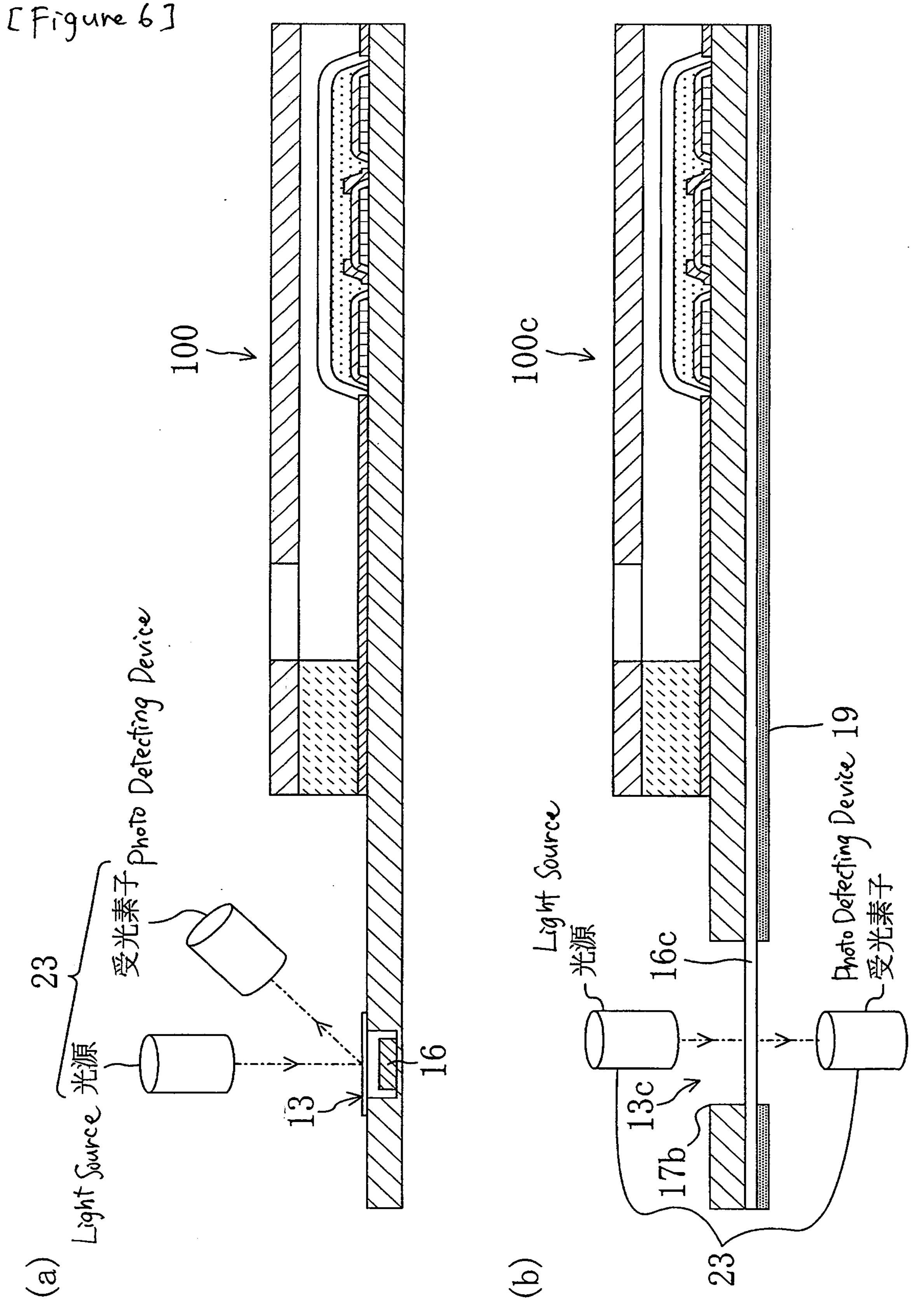
【図５】

[Figure 5]



【図６】

[Figure 6]



(a)
100
23
光源
Light Source
受光素子
Photo Detecting Device
13
16
(b)
100c
19
Light Source
光源
16c
Photo Detecting Device
受光素子
13c
17b
23

【図7】

[Figure 7]